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621. 397. 132.



RESEARCH DEPARTMENT



REPORT

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## A colour television illuminant consistency index

No. 1971/45



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**A COLOUR TELEVISION ILLUMINANT  
CONSISTENCY INDEX**

Research Department Report No. **1971/45**  
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A handwritten signature in black ink, appearing to read 'P. Langley', is positioned above the title 'Head of Research Department'.

Head of Research Department

(PH-81)



## A COLOUR TELEVISION ILLUMINANT CONSISTENCY INDEX

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## A COLOUR TELEVISION ILLUMINANT CONSISTENCY INDEX

## Summary

*A proposal is put forward for a quantitative method of assessing the suitability of lamps as sources of illumination in colour television broadcasting.*

## Foreword

The following document has been prepared for the EI-3.2 Colour Rendering Committee of the CIE for consideration at the 17th Session of the CIE at Barcelona. Although mainly the result of work carried out by Physics Section, Studio Group it has been revised and approved by the British EI-3.2 Committee of the CIE (Committee Internationale d'Eclairage).

## 1. General considerations

This paper outlines a possible method of specifying the degree of consistency of colour reproduction in colour television systems, in the presence of different scene illuminants. The discussion is restricted to the case in which a complete scene is lit by the light source whose spectral distribution is under consideration, thus permitting the camera to be balanced for this illuminant (by "balancing" is meant the adjustment of the individual channel sensitivities so that all channels give equal output signals when the camera views an achromatic scene area). The "mixed lighting" situation, in which the scene illumination comes from sources having different spectral distributions, and in which re-balancing of the camera for each individual source is not possible, is not considered further: the principles outlined below could however be used to derive a "mixed lighting consistency index".

The reason for choosing the term "consistency index", rather than the term "colour rendering index" used previously,<sup>1</sup> is that factors are present in the case of colour television transmission and viewing which are not relevant to direct viewing and which can affect the perceived colour (some of these factors also apply to or have counterparts in colour photographic reproduction and viewing). These factors include:—

- (a) The presence of a dark or dim surround to the picture, as the display tube is contained within a cabinet.
- (b) The characteristics of the complete transmission system, including the camera analysis characteristics and matrix coefficients,<sup>2</sup> the chromaticities of the display primaries, and the overall transfer characteristic of the system.
- (c) The white point of the display: this probably differs from that of the original scene.
- (d) The ambient illumination in which the display is viewed: this probably differs in chromaticity from the display white point.

- (e) The presence of flare (veiling glare) in the camera and the display, and the extent to which this flare is compensated.
- (f) Impairments to which the signal is subject along the transmission path.

Most of these factors are not under the control of the broadcasting authority, who can only state<sup>3</sup> the receiver and display parameters for which the radiated signals are intended. The subjective colour performance of the display (in other words the "colour rendering" of the original scene) is thus likely to differ from display to display and is therefore not capable of precise specification. On the other hand, the relative chromaticities and luminance values of different scene areas are well preserved in the transmission system, and experience has shown that consistency of colour reproduction is of extreme importance. The occasions on which inconsistencies of colour reproduction are liable to occur are

- i) When a familiar object or group of objects is displayed: the perceived colour reproduction may differ from the "memory colour" associated with the object by the observer, and the observer may be able to make a side-by-side comparison between the displayed object and an identical "real" object.
- ii) When two or more cameras present, in succession, pictures of the same scene (this includes the case of the scene sometimes being presented "live" and sometimes as an insert shot made at a different location with different lighting conditions).
- iii) At a programme change, when the picture source almost invariably changes.
- iv) When a viewer changes from one channel to another.

Category (i) above determines the subjective colour performance of the display as well as the colour consistency. Reproduction of skin tones is particularly important: only a very small change in chromaticity is required to make a

considerable subjective difference in the reproduction of skin tones, although for some relatively highly saturated colours considerable shifts in chromaticity can be tolerated. In this latter case it is important to preserve differences in chromaticity between one object and another. Inconsistencies occurring in category (ii) above are avoided as far as possible by the use of a rigorous line-up procedure in a studio, in which the outputs of all cameras are compared. Effects in categories (iii) and (iv) are reduced as far as possible by ensuring that signals from all sources correspond to a common specification.

The use of differing scene illuminants is potentially a further source of inconsistency of colour rendering in the displayed picture. Inconsistencies caused by the light sources under consideration having different chromaticities can be allowed for (in the case under consideration) by re-balancing the camera, but a residual effect remains as the detailed shape of the effective camera analysis characteristics is affected by the differences in spectral distribution of the light emitted from each source. This effect will be particularly apparent if the nature of the illuminants is very different (e.g. if one illuminant is relatively broad-band and another consists mainly of spectral lines).

The method of specifying the degree of consistency of colour reproduction between two light sources which is outlined in Section 2 has been derived with four considerations in mind:—

- A) The method of specification should give the most meaningful indication of the effect on the received and displayed picture of a change in scene illuminant.
- B) The method of specification should follow (as far as possible) the C.I.E. recommended method<sup>1</sup> of specifying the colour rendering properties of light sources.
- C) The method chosen should consist of a series of calculations which represent the optical and electrical processes which occur in a practical colour television transmission system.
- D) The magnitude of the index (or indices) so calculated should represent the same subjective evaluation of consistency of colour rendering as that indicated by an index calculated for illuminants in their own right by the C.I.E. recommended method.

## 2. The proposed method of calculating the television index

A colour television camera (see Appendix I) within a (lightproof) studio is assumed to be connected to a colour display device having display primaries\* and white point\*\* corresponding to those specified for the PAL colour

television system in accordance with the 625-line System I employed within the U.K.<sup>3</sup> The studio illumination is first assumed to be derived entirely from the light source whose colour rendering properties are under consideration (the spectral power distribution of this source will be referred to as the "test illuminant"). The colour camera is colour-balanced under these conditions, so that all channels give full ("peak-white") output when the camera views a reference white (see Appendix IV). The colour camera is then assumed to view, in turn, each of a selection of test colours (see Appendix II). For each colour (say the  $i^{\text{th}}$ ) the chromaticity co-ordinates ( $u_{iT}$ ,  $v_{iT}$  in the 1960 CIE-UCS co-ordinates) and the luminance  $L_{iT}$  (relative to peak-white luminance = 100%) exhibited by the colour display are calculated. The studio illumination is then replaced by a light source having a spectral power distribution corresponding to a suitable reference illuminant (see Appendix III), the camera colour balance is re-adjusted, and the displayed chromaticity and luminance values ( $u_{iR}$ ,  $v_{iR}$  and  $L_{iR}$ ) exhibited by the colour display are calculated. The colorimetric error vector length ( $\Delta E_{ti}$ ) for the  $i^{\text{th}}$  test colour is then calculated using the formula\*

$$\Delta E_{ti} = \left\{ \left[ \frac{f(L_i)}{W_{iR}^* - W_{iT}^*} \right]^2 + 13^2 \left[ \frac{f(u_i)}{W_{iR}^* - W_{iT}^*} \right]^2 + 13^2 \left[ \frac{f(v_i)}{W_{iR}^* - W_{iT}^*} \right]^2 \right\}^{1/2} \quad (1)$$

$$f(u_i) = W_{iR}^* (u_{iR} - u_w) - W_{iT}^* (u_{iT} - u_w)$$

$$f(v_i) = W_{iR}^* (v_{iR} - v_w) - W_{iT}^* (v_{iT} - v_w)$$

$$W_{iR}^* = 25L_{iR}^{1/3} - 17$$

$$\text{and } W_{iT}^* = 15L_{iT}^{1/3} - 17$$

and where subscripts R refer to the reference illuminant, subscripts T refer to the test illuminant, subscripts w refer to the display white point, and the subscript t distinguishes the annotated quantity from the similar quantities defined in Reference 1.

An "individual television illuminant consistency index" (I.T.I.C. index) is then calculated for each test colour, using the formula.\*\*

$$R_{ti} = 100 - K_i \Delta E_{ti} \quad (2)$$

where  $K_i$  is the "weighting constant" appropriate to the  $i^{\text{th}}$  test colour (see Appendix II)

When this calculation has been made for all test colours, three quantities are quoted as the final rating for the test illuminant:—

- (a) The worst (i.e. numerically lowest) of the I.T.I.C. indices are calculated above.
- (b) The test colour giving rise to this worst index.
- (c) The average value ( $R_t$ ) of the indices obtained for all the test colours.

\* Reference 3 Section 5.1

\*\* Reference 3 Section 4.3.4

\* Based on Equation 3 of Reference 1

\*\* Based on Equation 1 of Reference 1



Items (a) and (b) are included on the grounds that poor consistency of reproduction of one colour will represent a serious shortcoming of the test illuminant, even if all other colours are reproduced with good consistency. Item (c) is included as a measure of the degree to which poor consistency of reproduction is distributed over the range of test colours (e.g. a low value for item (a) and a much higher value for item (c) would indicate that a few colours were reproduced with much poorer consistency than the rest).

It is possible to envisage methods by which the significance of the consistency index could be extended. In particular, it would be an advantage to preserve the (three-dimensional) vector nature of the individual indices. Account could then be taken of such factors as the preservation of differentials in the chromaticity and luminance values of the displayed test colours on change of illuminant: this could include the preservation of metameric colour matches as a special case.

The term "individual" index is thought to be preferable to the term "special" index used by the C.I.E. This latter term should be restricted to indices obtained for colours other than those specified for the above calculations.

### 3. References

1. Method of measuring and specifying colour rendering properties of light sources. C.I.E. Publication No. 13, 1965.
2. JONES, A.H., 1967. Optimum colour analysis characteristics and matrices for colour television cameras with three receptors. *J.Soc.Motion Pict.Telev.Engrs.*, 1968, **77**, 2, pp. 108-115.
3. Specifications of television standards for 625-line system-I transmission. BBC-ITA publication, January 1971.
4. 2nd Edition of reference 1 (in draft) section 6.4.
5. HALSTEAD, M.B. et al, 1970. Colour rendering tolerances in the C.I.E. system. *Lighting Research and Technology*, 1971, **3**, 2, pp. 99-124.
6. C.C.I.R. XII Plenary Assembly. New Delhi, 1970. Vol. V Part 1. Recommendation 265-2. Sections 3.4.1 and 3.4.2, pp. 214-5.
7. LENT, S.J., 1970. BBC test chart 57, A new grey-scale reflectance chart for colour cameras. *Radio & Electron. Engr.*, 1971, **41**, 5, pp. 237-240.

## APPENDIX I

### *The Definition of a Standard Colour Television Camera*

#### ANALYSIS

The requirement (paragraph C, Section 1), that the calculation of the television colour rendering index should be based on a practical camera chain, precludes the adoption of a rigorously "ideal" set of parameters for the standard camera used in these calculations. This situation occurs because the design of a practical camera represents a compromise between many conflicting factors (for example, colour fidelity, sensitivity, complexity and cost). The most important practical limitations are, in the present context, as follows:—

- (a) The number of photosensitive receptors must be restricted. Normally three receptors (red, green and blue) are used; sometimes a fourth (luminance) is added.
- (b) The displayed picture white point usually differs from that of the original scene.
- (c) The analysis characteristic of each photosensitive receptor is invariant for any one camera and consists of one "positive lobe". Although an approximation to the "negative lobes" which appear in any ideal analysis characteristic based on practically-realizable display primaries may be obtained by using

interconnections<sup>2</sup> between the three channels, the proportions (defined by a 3 x 3 matrix) in which the signals from the three channels are interconnected are also usually invariant for any particular camera type (although in some cases different matrix coefficients may be specified for "studio" and "daylight" use).

- (d) For any wavelength at which more than one photosensitive receptor has significant response, the sum of the ordinate values defining the response of each receptor must not exceed 100%. A loss of efficiency in the utilisation of light is inevitable if this condition is not observed.

It is suggested that the most satisfactory approach to be adopted in defining a standard analysis is to specify a set of characteristics representative of current\* "good practice" while not referring to the actual characteristics of any currently-manufactured camera. For simplicity of calculation it is preferable to adopt a three-tube (red, green and blue) system as standard.

\* It may be necessary to specify two sets of characteristics: one referring to "normal" lead oxide camera tubes having no sensitivity to radiation of longer wavelength than 650 nm, and another not incorporating this restriction.

Suitable matrix coefficients for use with this analysis can be calculated<sup>2</sup> by using an optimisation procedure in which the coefficient values are adjusted (within defined limits) to give the lowest colorimetric differences between a set of test colours\* as reproduced on a colour display and the same set of test colours in the illuminant corresponding to the display white point.

Preliminary calculations suggest that the calculated values of the individual indices appear to be related to the general colorimetric accuracy given by the camera analysis characteristic.\*\* The index values obtained when the optimised matrix was included in the calculations (so that the calculations referred to a camera having good objective colorimetric accuracy as described above) were considerably lower (i.e. less favourable) than when the matrix was omitted from the calculations. This suggests that although the camera analysis characteristics, including matrix, must represent current good practice (since a poor analysis characteristic may lead to an unduly optimistic value of index), it is not desirable to derive a non-representative characteristic (for example, by optimising the matrix coefficients for best performance over the standard test colours, to the exclusion of all other colours) as this might lead to an unduly pessimistic value of index.

\* This set of test colours should include a wide gamut of colours which fully explores the total available range of colours determined by the display primaries.

\*\* The procedure (see Appendix II) of weighting the index values corresponding to different test colours would tend to reduce this effect.

Ordinate values for a suitable set of "quasi-practical" characteristics representative of "normal" lead-oxide tubes are given in Table I.1 and are also shown in Fig. I.1. These characteristics refer to equi-energy illuminant. Optimised matrix coefficients for use with this analysis are shown in the relationship:—

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} 1.628 & -0.640 & 0.012 \\ -0.116 & 1.204 & -0.088 \\ -0.008 & -0.177 & 1.185 \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix}$$

Consideration of the spectra of some proposed studio light sources indicates that ordinate values taken at 5 nm intervals are likely to be satisfactory, but that a 10 nm sampling interval is probably too coarse.

#### OVERALL TRANSFER CHARACTERISTIC OR "GAMMA"

It is current practice to operate a colour television channel at an overall gamma of approximately 1.2: i.e. the relation between the original luminance (relative to peak white) at the surface of a photoreceptor and the corresponding relative luminance of the excitation of the display primary is given by the expression

$$L_{Display} = (L_{Original})^{1.2}$$

This relationship should therefore be included in the calculation of the television colour rendering index.

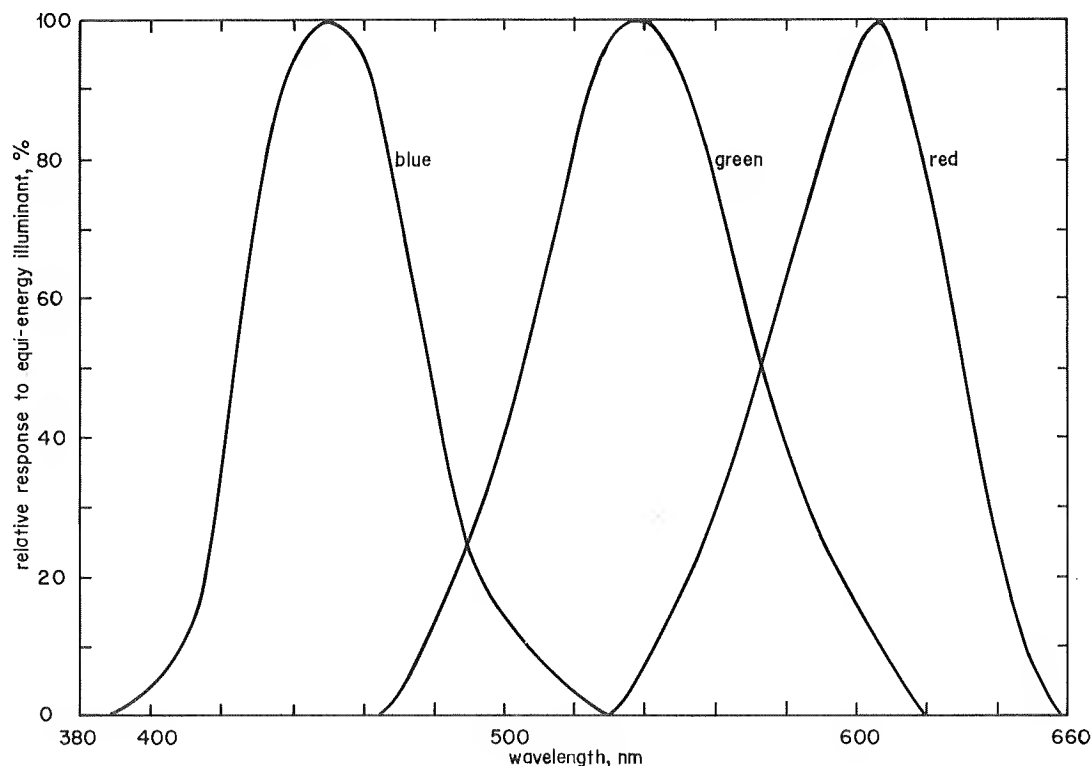


Fig. 1.1 - 'Quasi-practical' camera analysis characteristics in equi-energy illuminant

TABLE I.1

*'Quasi-practical' Camera Analysis Characteristics in Equi-energy Illuminant*

Red Channel		Green Channel		Blue Channel	
Wavelength nm	Response %	Wavelength nm	Response %	Wavelength nm	Response %
530	0	460	0	380	0
535	3.4	465	0.2	385	0.3
540	7.7	470	2.4	390	1.1
545	12.3	475	7.7	395	2.2
550	18.0	480	13.3	400	3.8
555	23.9	485	19.0	405	6.6
560	29.8	490	25.0	410	11.3
565	37.0	495	31.8	415	20.2
570	45.0	500	40.5	420	37.2
575	53.9	505	51.1	425	57.8
580	63.8	510	62.3	430	78.3
585	73.5	515	72.8	435	88.9
590	84.0	520	84.0	440	94.4
595	91.8	525	91.6	445	98.8
600	97.1	530	96.3	450	100.0
605	100.0	535	99.6	455	98.2
610	96.9	540	99.6	460	93.8
615	86.0	545	97.3	465	85.0
620	74.8	550	93.4	470	72.0
625	63.9	555	85.9	475	58.0
630	51.2	560	74.7	480	43.9
635	37.9	565	63.3	485	31.9
640	24.1	570	54.4	490	23.6
645	13.1	575	46.3	495	18.5
650	6.8	580	38.6	500	14.1
655	2.7	585	32.1	505	11.0
660	0	590	26.3	510	8.0
		595	21.0	515	5.3
		600	15.7	520	2.9
		605	10.8	525	1.1
		610	6.4	530	0.1
		615	2.9	535	0
		620	0.2		
		625	0		

## APPENDIX II

*Trial Calculations of the Television  
Illuminant Consistency Index*

This appendix describes trial calculations made to test the validity of the Television Illuminant Consistency Index. Twenty-five test colours were selected for these calculations although it is hoped that the final specification of the index can be based on fewer colours. The colours are identified

as shown in Table II.1. The chromaticities of the test colours in  $D_{65}$  illumination are shown in Fig. II.1. A reference white reflectance level of 60% was adopted (see Appendix IV).

TABLE II.1  
Test Colours for Consistency Index

Colour No.	Colour Description	Origin of Colour
1	Desaturated blue	BBC No. 9
2	Desaturated cyan	BBC No. 10
3	Desaturated green	BBC No. 11
4	Desaturated yellow	BBC No. 12
5	Desaturated orange	BBC No. 13
6	Desaturated red	BBC No. 14
7	Desaturated pink	BBC No. 15
8	Desaturated magenta	BBC No. 16
9	Skin tone	BBC No. 17
10	Skin tone	BBC No. 18
11	Skin tone	BBC No. 19
12	Skin tone	BBC No. 20
13	Skin tone	BBC No. 21
14	Skin tone	BBC No. 22
15	Skin tone	BBC No. 23
16	Skin tone	BBC No. 24
17	Munsell 7.5 R6/4	CIE No. 1
18	Munsell 5 Y6/4	CIE No. 2
19	Munsell 5 GY6/8	CIE No. 3
20	Munsell 2.5 G6/6	CIE No. 4
21	Munsell 10 BG6/4	CIE No. 5
22	Munsell 5 PB6/8	CIE No. 6
23	Munsell 2.5 P6/8	CIE No. 7
24	Munsell 10 P6/8	CIE No. 8
25	Munsell 5 YR8/4	CIE No. 13

Two test sources were used: both were metal-arc discharge lamps, having correlated colour temperatures of 3400 K and 3700 K, and are referred to as "Source 1" and "Source 2" respectively. The spectra of these sources are shown in Figs. II.2 and II.3.

The calculated I.T.I.C. indices for each of these two sources, using a P 3000 reference illuminant (see Appendix III), are shown in Table II.2 for the case in which the "weighting constant"  $K_1$  (Equation (2)) took the value\* 4.6 for all test colours. It can be seen that there is great disparity between the values of indices obtained from each of the test colours, and the difficulty immediately arises as to how to give a meaningful interpretation of these results. It is, for example, known that a considerable shift in displayed chromaticity and luminance of some colours (and therefore a relatively low value of the I.T.I.C. index) may be permitted before the perceived effect of such a shift becomes displeasing, while for other colours only a small colour shift is permissible before the effect is judged to be displeasing. Skin tones are perhaps the best-known example of the latter category of colours: the position here is further complicated because it appears that shifts in some directions (e.g. changes in saturation) are more acceptable than shifts in other directions (e.g. of hue, particularly along the green-magenta axis). Furthermore, the degree to which the effect of a change of illuminant on a particular test colour is taken into account ought to be related to the probability of occurrence of that colour (or one closely related to it) in a televised scene. Strictly speaking, the term "colour" as used in the above discussion refers to the spectral characteristics of the colour and not just to the tristimulus coefficients, as colours which are a

\* as in Equation 1 of Reference 1

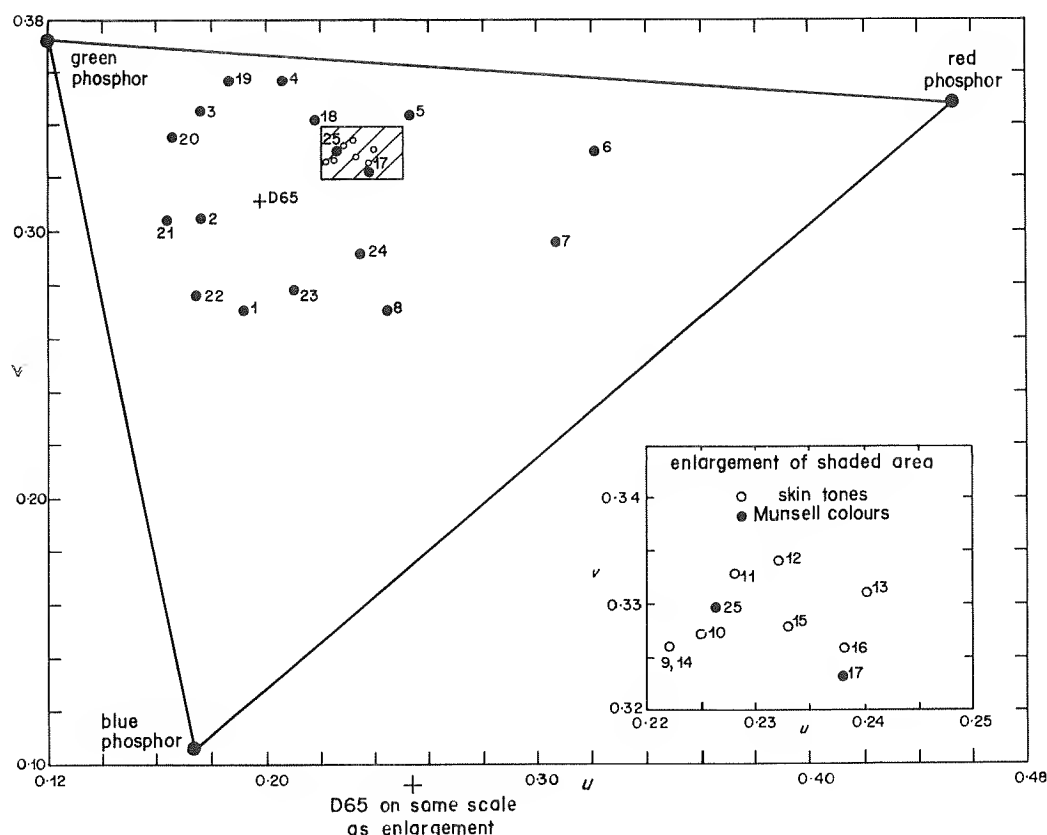


Fig. II.1  
Chromaticities of  
test colours

metameric match to a colour television system in one illuminant will not necessarily remain so when the illuminant is changed.

Little evidence exists at present which would enable the effects outlined in the above discussion to be expressed in meaningful numerical terms (e.g. by ascribing definite values of the weighting constant  $K_i$  to particular test colours). One approach to this problem has been to calculate the I.T.I.C. values for a change of illuminant (P 3000 to  $D_{65}$ ) which is known from experience to give

acceptably consistent colour reproduction. The results of this calculation are shown in Table II.3. Although this calculation does not provide enough evidence for the derivation of meaningful values of  $K_i$ , certain trends are evident. For example, it can be seen that some colours (e.g. numbers 6, 7 and 8) which gave very low I.T.I.C. values for test sources 1 and 2 also give low I.T.I.C. values for the P 3000/ $D_{65}$  comparison. This suggests that the very low I.T.I.C. values obtained for these colours when using Sources 1 and 2 are (at least, to some extent) misleading.

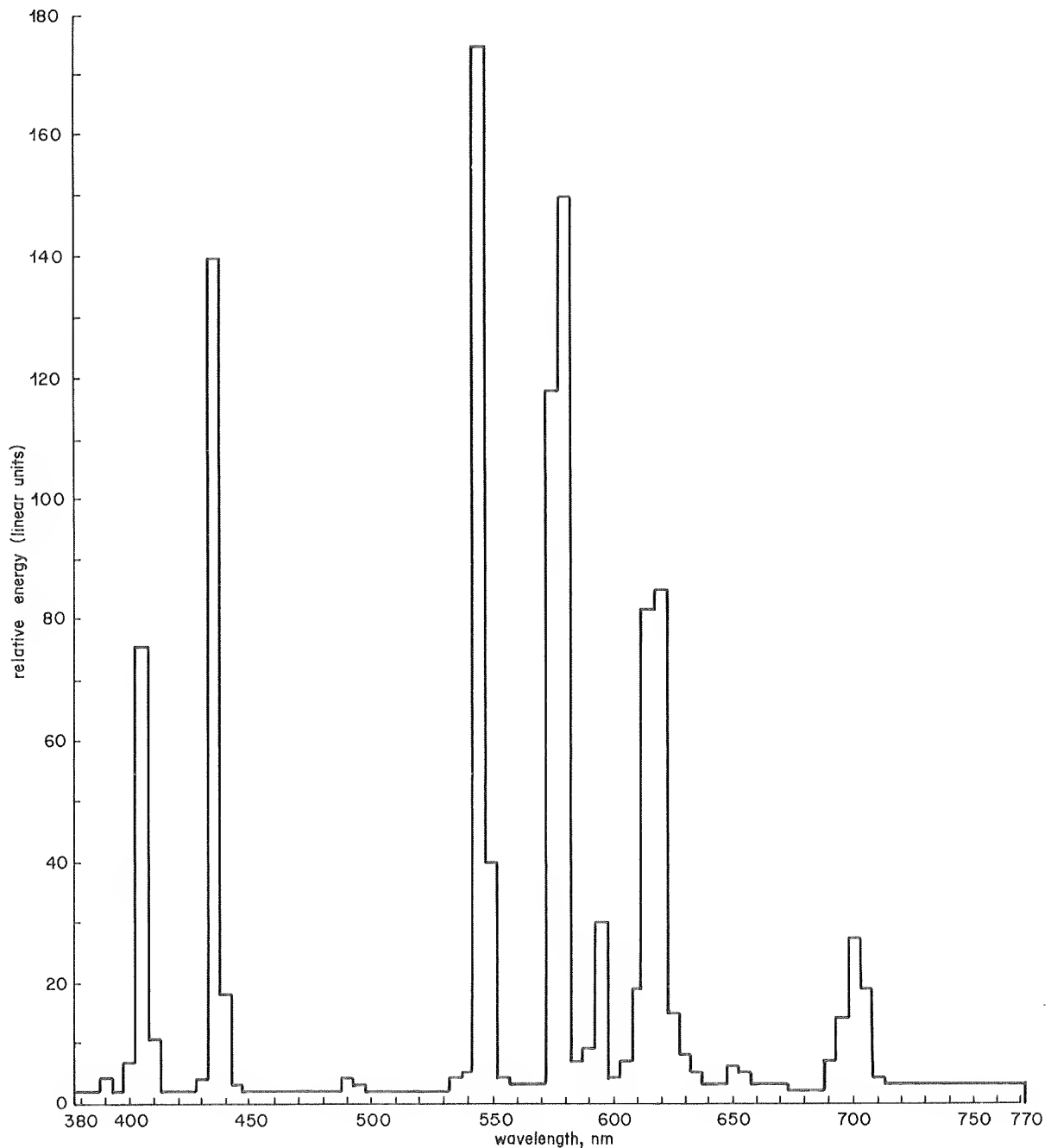


Fig. 11.2 - Source 1: Spectral distribution (in bands of 5 nm)

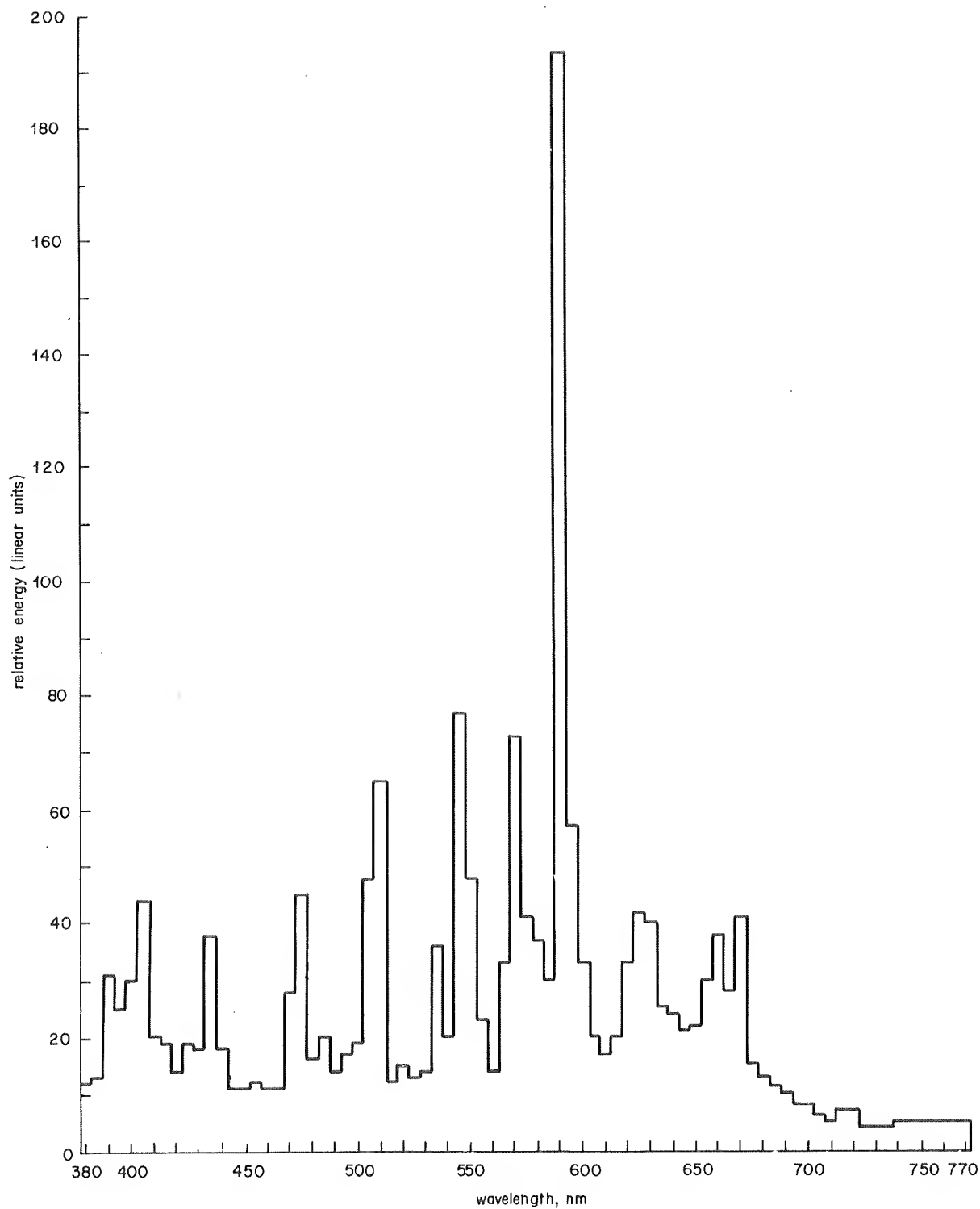


Fig. 11.3 - Source 2: Spectral distribution (in bands of 5 nm)

A difficulty also arises in specifying the limiting value of the I.T.I.C. index, such that a value below this limit represents an unacceptable degree of inconsistency between the test and reference light sources. One source<sup>4</sup> states that "differences in  $R_i$  (which in present terms is equivalent to differences in I.T.I.C. index) of about five units will correspond to visually perceptible colour differences under

the best conditions". This would suggest a limiting value of 95 for the I.T.I.C. index. On the other hand, recent work<sup>5</sup> has shown that a limiting value of about 85\* might be more appropriate.

\* this value is obtained by averaging the results in Column 5 of Table 5 in Reference 5.

TABLE II.2

ITIC Indices

Test Colour	ITIC Indices	
	Source 1	Source 2
1	26.7	89.2
2	61.9	71.4
3	48.1	67.8
4	43.5	94.9
5	9.9	48.7
6	34.3	-44.4
7	11.2	-46.8
8	-2.9	11.5
9	53.9	52.4
10	40.8	44.7
11	42.0	53.2
12	50.5	66.4
13	63.9	61.5
14	82.4	91.7
15	50.6	45.6
16	57.2	28.6
17	47.8	64.5
18	61.7	93.3
19	48.4	78.8
20	35.1	70.6
21	55.8	78.4
22	44.2	95.4
23	34.7	65.8
24	30.2	28.3
25	49.5	76.6
Mean	43.3	55.5

TABLE II.3

P 3000/D<sub>65</sub> Comparison

Test Colour	ITIC Index
1	80.2
2	89.5
3	82.0
4	81.0
5	78.3
6	56.1
7	43.4
8	53.3
9	85.8
10	82.1
11	91.4
12	95.7
13	93.4
14	96.2
15	85.2
16	79.0
17	86.7
18	83.7
19	70.8
20	75.4
21	80.0
22	74.9
23	79.0
24	68.6
25	82.6
Mean	79.0

## APPENDIX III

*The Choice of Reference Illuminant*

In calculating the C.I.E. colour rendering index, the reference illuminant is "intended to be the same or nearly the same as the lamp to be tested".\* It is however proposed that, in calculating the Television Illuminant Consistency Index, the choice of reference illuminant should be restricted to two cases, as shown in Table III.1. This restriction is preferable for two reasons:-

- (a) The purpose of the Television Illuminant Consistency Index is to indicate the degree of consistency of colour reproduction on changing from "conventional" television lighting to lighting using the test source. Test sources having a correlated colour temperature below 5000 K would normally be used to replace conventional

tungsten studio lighting, which has a spectral distribution approximating to that of a Planckian radiator at 3000 K. Similarly, the use of test sources of higher correlated colour temperature than 5000 K can be regarded as an approximation to operating the camera under "daylight" conditions (although this mode of operation is not so well-defined as is the case with studio lighting).

- (b) As the camera is colour-balanced in each illuminant (reference and test) the problems associated with colour adaptation do not occur. There is thus no necessity for choosing a reference illuminant having a very similar chromaticity to that of the test illuminant.

\* Reference 3 Section 4.3

TABLE III.1

## Reference Illuminants

Correlated Colour Temperature of Test illuminant	Reference illuminant
$\leq 5000$ K	Planckian radiator having colour temperature of 3000 K
$> 5000$ K	Daylight illuminant D <sub>65</sub>

Circumstances may arise in which the degree of consistency of colour reproduction between two "non-standard" light sources may be required. In such cases it is not necessarily sufficient that the two sources have the same numerical value of consistency index, as each "individual" index is a vector quantity of unspecified direction. It would be more appropriate to treat one of the light sources as "test" and the other as "reference" and calculate a "mutual" consistency index between the two sources.

## APPENDIX IV

## The Choice of Reference White

In the C.I.E. recommended method<sup>1</sup> of specifying the colour rendering properties of light sources, the ordinate values specifying the spectral characteristics of the test colours are defined relative to the "perfect diffuser"\* (100% diffusely reflecting at all wavelengths). It is common practice, on the other hand, to limit the light reflected from the bright areas in a televised scene to about 60% of the incident light and to set up the camera using a 60% diffuse neutral reflector as reference "white" (i.e. so that the output from each channel is at its maximum value when viewing this reflector)<sup>6,7</sup>. This is done so that, with normal camera exposure, facial skin tones are displayed on the receiver at subjectively acceptable luminance levels. If much higher maximum reflectances are present, the high overall "gamma" of the system would cause faces to be reproduced at an unacceptably low luminance level. It does not necessarily follow that all television scenes are exposed using precisely this peak reflectance value: sometimes (particularly in Outside Broadcast programmes) the camera iris is adjusted so that the peak magnitude of the greatest colour-separation signal equals the permitted peak level. Nevertheless, the value of 60% may be taken as representative of the reference white reflectance in television scenes. The considerations B and C listed in Section 1 are therefore in conflict at far as the choice of reference white is concerned: however, as Consideration B is in other respects not strictly observed, it seems preferable to follow Consideration C and thus to adopt the 60% reference white reflectance value. The second and third columns of Table IV.1 show, for Source 1, the I.T.I.C. indices calculated using the two values of reference white reflectance value, while the fourth column of this Table shows the ratio of the  $\Delta E_{ti}$  values (see Equations 1 and 2) obtained for the two conditions. It can be seen that the result of changing the reference white reflectance value is to multiply the value of  $\Delta E_{ti}$  by a value which is effectively constant for all test colours: this could be accommodated simply by multiplying the weighting constant  $K_i$  by the inverse factor.

The I.T.I.C. values shown in Tables II.2 and II.3 were calculated using a reference white reflectance value of 60%.

\* See footnote to Table 1 of Reference 1

TABLE IV.1

Comparison of ITIC Index Values for Source 1 using 100% and 60% Reference White Reflectance Values

Test Colour	I.T.I.C. Index Values for Indicated Reference White Reflectance Values		The Ratio $\frac{\Delta E_{ti(60\%)}}{\Delta E_{ti(100\%)}}$
	100% Reflectance	60% Reflectance	
1	43.9	26.7	1.31
2	70.2	61.9	1.28
3	59.5	48.1	1.28
4	55.6	43.5	1.27
5	29.8	9.9	1.28
6	47.6	34.3	1.25
7	30.7	11.2	1.28
8	20.5	-2.9	1.29
9	64.0	53.9	1.28
10	54.0	40.8	1.29
11	55.1	42.0	1.29
12	62.2	50.5	1.31
13	73.0	63.9	1.34
14	87.4	82.4	1.39
15	61.7	50.6	1.29
16	66.7	57.2	1.28
17	59.7	47.8	1.30
18	70.4	61.7	1.30
19	59.5	48.4	1.27
20	50.0	35.1	1.30
21	65.8	55.8	1.29
22	57.0	44.2	1.30
23	49.8	34.7	1.30
24	46.1	30.2	1.30
25	60.5	49.5	1.28
Mean	56.0	43.3	1.29